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Snag Characteristics in Old-Growth Forests on Prince of Wales Island, Alaska

Wildlife and Fisheries Habitat Management Notes

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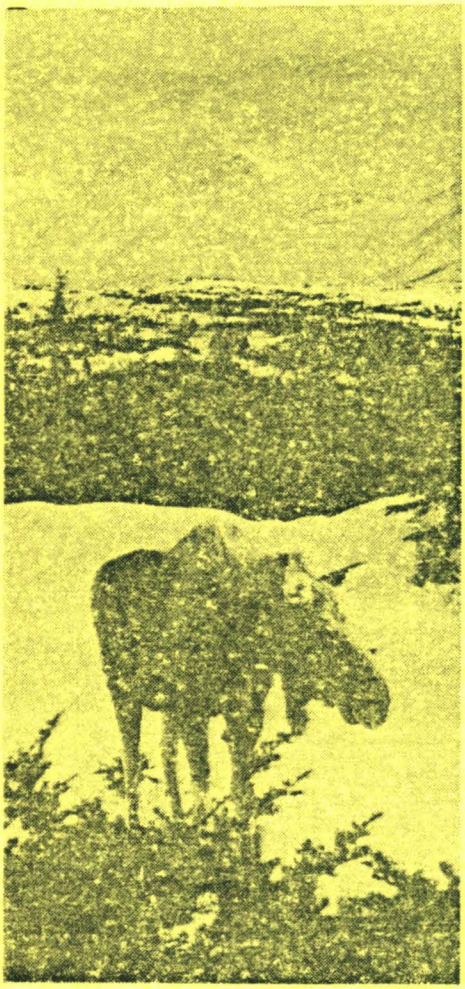

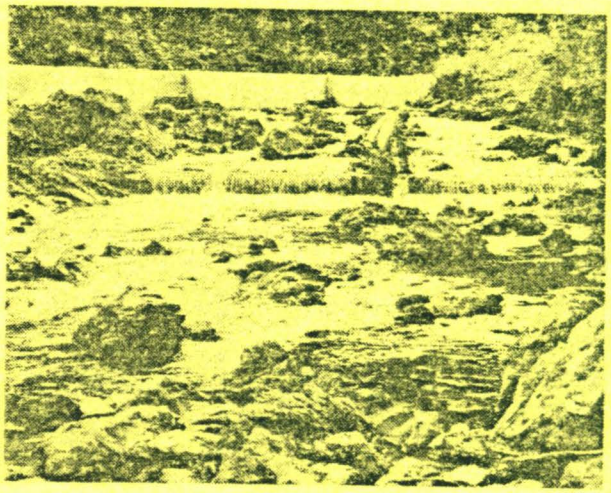

Snag Characteristics in Old-Growth Forests on Prince of Wales Island, Alaska

By Robert E. Noble and Paul Harrington[1/]

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Snag Characteristics in Old-Growth Forests on Prince of Wales Island in Alaska, by Robert E. Noble and Paul Harrington. U.S. Department of Agriculture, Forest Service, Alaska Region (P.O. Box 1628, Juneau, Alaska 99802).

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Introduction

The Tongass National Forest embraces about 15.4 million acres, most of southeastern Alaska. It was established in 1907 by proclamation of President Theodore Roosevelt. Except for mostly shoreline logging, the Tongass remained relatively untouched until early in the fifties. Extensive timber harvesting began in 1954, and the present annual cut on the Tongass approaches 400 million or more boardfeet. Practically all the timber is removed by clearcutting. Today, Forest Service policy limits the size of harvesting areas to units no larger than 160 acres. In Alaska, most units are now much smaller than the limit.

Foresters estimate a rotation of 100 to 150 years for the hemlock-spruce forests of southeastern Alaska. The rotation is the time required for a clearcut site to produce another crop of harvestable timber. Forest managers do not expect trees to grow to the size of those found in old-growth stands, ("old-growth" is an euphemistic term foresters apply to virgin, pristine forests) since these trees are commonly 300 to 500 years old or older.

Such a relatively short rotation gives the stand little time to produce the snags so common in the old-growth stands being harvested. Indeed, it is the opinion of Noble (1978) that the 100-150 year rotation is an optimistic estimate. Noble measured tree regeneration in a 23-year-old clearcut near Hollis in July 1977. About 63 percent of the stand consisted of western hemlock (Tsuga heterophylla) and 23 percent was Sitka spruce (Picea sitchensis). The maximum diameter at breast height (dbh) was 8 inches, and the average dbh was about 5 inches. Maximum height was 35 feet, but the average height was about 25 feet. Growth varies with site and a host of other factors, but the 23-year-old stand Noble measured will never produce, in 150 years, marketable logs anywhere near the size of the originally harvested trees.

These managed stands of hemlock, hemlock-spruce, and spruce will not offer the density, size, nor age of snags such as existed in virgin forest. It is imperative that the snag component of old-growth stands be documented because the virgin stands are being harvested at an accelerated rate. Most of the virgin timber in this country and throughout the world was cut before studies were made of the snag component. As an example, much of the southeastern United States was covered by extensive stands of American beech (Fagus grandifolia), magnolia (Magnolia spp.), longleaf pine (Pinus palustris), and other climax or subclimax types when Europeans first arrived on the continent. There is no information on the snag component of those forests, and the extensive virgin timber stands were harvested long ago.

Multiple use in the Tongass National Forest requires knowledge of the snag component of old-growth stands. It is necessary to know what wildlife species depend upon the snags, and to what extent, for their existence. It will be necessary to create snags in future intensively managed stands to simulate as closely as possible the natural conditions that exist in old-growth. Such management will require detailed information which can only be obtained by studying snags in existing old-growth stands. This study was designed to provide some of these data plus directions for more detailed and specific research.

The Study Area

All but 23 of the 315 sample plots were established within a triangular area of about 24,000 acres on central Prince of Wales Island, 48 miles northwest of Ketchikan, Alaska. The area was enclosed by a north-south line originating at the southeastern tip of Big Salt Lake (NW 1/4, NW 1/4, S 24, T72S, R81E) and extending north to the NW 1/4, S 11, T71S, R81E then ESE to the Thorne River in SE 1/4, SE 1/4, T71S, R83E, thence southwest to the starting point at the southeastern tip of Big Salt Lake. Control Lake lies approximately in the center of this triangular area (Fig. 1).

Twenty-three plots were taken in sections 29 and 32, T68S, R79E on the west side of Sarkar Lake. This area is about 22 airline miles northwest of Control Lake. In addition, snags were observed in old-growth stands along the Big Salt Road from Control Lake to Craig, in the vicinity of Klawock and along Staney Creek.

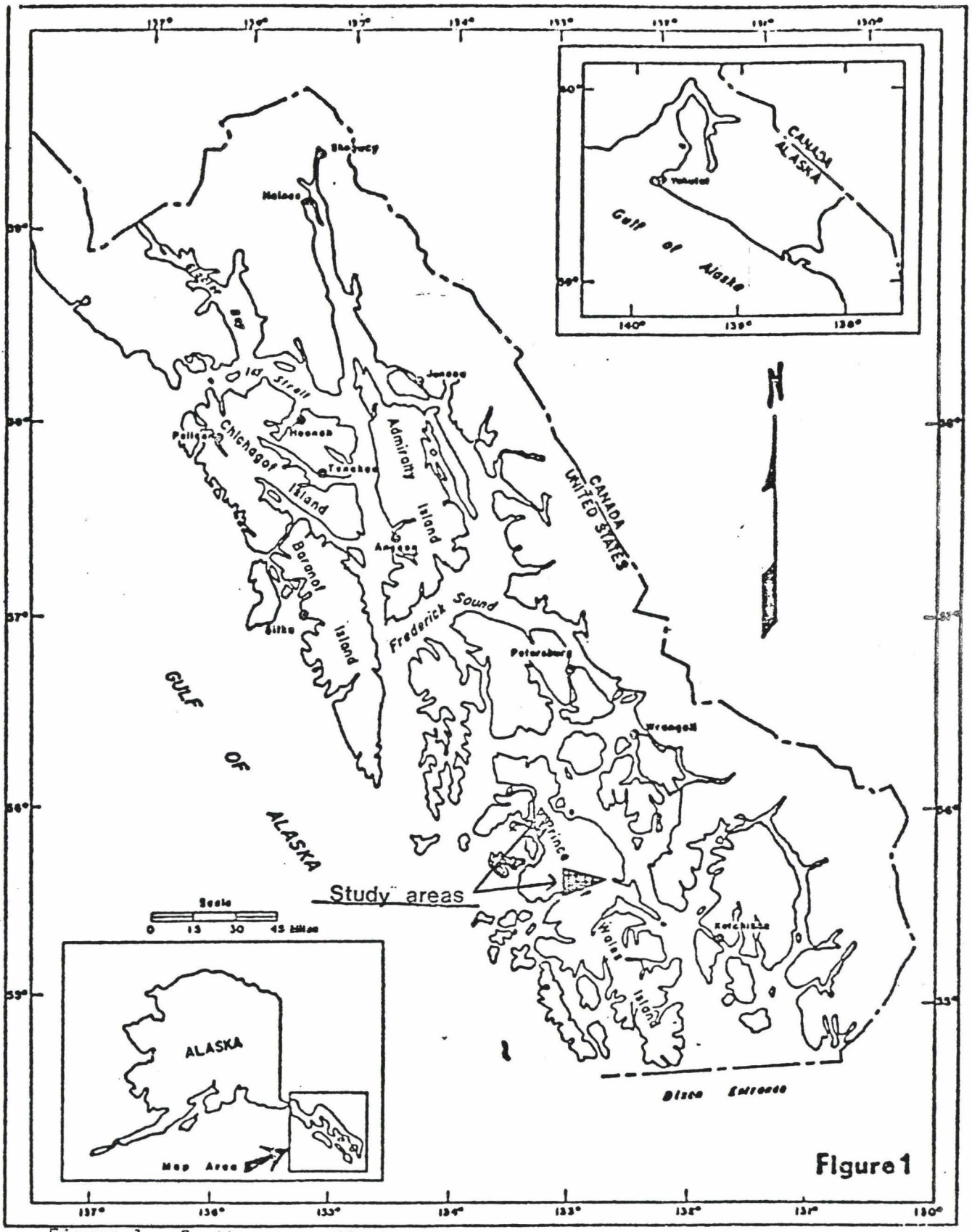

Figure 1. Southeastern Alaska with the study areas on Prince of Wales Island indicated by cross-hatched triangles, 1977.

Methods

A "snag", for purpose of this study, was defined as any standing dead tree or part of a dead tree at least 10 inches in diameter at breast height (dbh) and 10 feet tall.

Snags in old-growth stands were sampled using 0.2-acre circular plots with plot centers located 250 feet apart on established compass lines. These centers were obtained by tying a 200-foot cloth tape to a Jacob staff. One person held the last plot center while two others with a compass proceeded ahead on the bearing trailing the tape behind. They were stopped by the first person after 200 feet. One of the pair held the 200-foot point while the compass bearer moved an additional 50 feet to erect the Jacob staff at plot center. From plot center the tally-person extended the tape 52.7 feet (radius of a 0.2-acre circular plot) to establish the periphery of the plot.

These variables were determined for each plot:

1. Stand type
2. Elevation (above sea level)
3. Slope (degree of)
4. Basal area per acre
5. Crown density (percentage)
6. Height of dominant canopy
7. Number of snags below minimum (snags less than 10 inches dbh and/or less than 10 feet tall; no snag below 3.5 inches dbh [= 4 inches] were considered regardless of height).
8. Number of snags
9. Number of trees in dominant canopy

Stand type was determined from Forest Service timber type maps dated 1975. Old-growth is a generic term, and there are 6 possible stand compositions:

Hemlock (Tsuga heterophylla and/or Tsuga mertensiana)

Spruce (Picea sitchensis)

Hemlock and Spruce

Cedar (Thuja plicata and/or Chamaecyparis nootkatensis)

Red Alder (Alnus rubra)

Black Cottonwood (Populus trichocarpa)

Old-growth stands have 3 possible stocking rates: poorly stocked, medium stocked, and well stocked. There are 4 possible volume classes:

8,000 to 20,000	boardfeet per acre
20,000 to 30,000	boardfeet per acre
30,000 to 50,000	boardfeet per acre
50,000 or more	boardfeet per acre

Three categories for the composition of old-growth cedar (Thuja plicala) and/or Chamecyparis nootkatensis) are: 0 to 5 percent, 6 to 25 percent and 26 to 50 percent.

Eleven different old-growth stand types were sampled (table 1) between July 19, 1977 and August 17, 1977. During this period data were gathered during 21 days. Four-hundred hours in field work were spent collecting data on 1,003 snags in 315 0.2-acre circular plots. An additional 36 hours were spent in camp transferring data from field notebooks to computer code sheets. Punching data on computer cards, checking computer printouts, analyzing data, reviewing literature, and writing the final report required 275 hours.

Table 1. Old-growth stand types sampled for snags, Prince of Wales Island, Alaska, July and August, 1977.

Old-growth stand type	Type Abbreviation	Number of 0.2-acre plots taken
Hemlock, 8,000 to 20,000 boardfeet per acre 1/, well stocked, high risk decadent rate	H4	21
Hemlock, 20,000 to 30,000 boardfeet per acre, well stocked, high risk decadent rate	H5	45
Hemlock, 30,000 to 50,000 boardfeet per acre, well stocked, high risk decadent rate	H6	33
Hemlock, 50,000 or more boardfeet per acre, well stocked, high risk decadent rate	H7	43
Sitka spruce, 50,000 or more board-feet per acre, well stocked, high risk decadent rate	S7	14
Hemlock-Sitka spruce, 20,000 to 30,000 boardfeet per acre, well stocked, high risk decadent rate	HS5	14
Hemlock-Sitka spruce, 30,000 to 50,000 boardfeet per acre, well stocked, high risk decadent rate	HS6	51
Hemlock-Sitka spruce, 50,000 or more boardfeet per acre, well stocked, high risk decadent rate	HS7	31
Cedar, 8,000 to 20,000 boardfeet per acre, well stocked 2/	C4	2
Low site, unproductive commercial forest	ScL	31
Muskeg forest, unproductive com-mercial forest	ScM	30

1/ Scribner scale was used for measuring boardfeet.

2/ Cedar - *Thuja plicata* and/or *Chamaecyparis nootkatensia*

The following determinations were made for each snag within a plot:

1. Species
2. Diameter-at-breast-height (dbh)
3. Soundness
4. Top (condition of)
5. Percentage covered by bark
6. Degree lean from vertical
7. Number of limbs
8. Percentage above canopy
9. Distance to nearest living tree in overstory
10. Distance to nearest snag
11. Number of natural cavities
12. Number of animal-made cavities
13. Age
14. Height

Variables recorded for each plot were determined as follows:

*Elevation was measured with a pocket altimeter.

*Slope was estimated with a Sunnto clinometer by taking two readings from plot center; one downhill and one uphill. The average of the two readings was an estimate of percentage of slope. Percentage of slope was converted to degree of slope.

*Basal area per acre was read from plot center with a calibrated wedge prism.

*Percentage crown density was ocularly estimated from plot center.

*Height of the dominant overstory was measured with a clinometer by selecting one tree within 200 feet of plot center that was representative of the dominant overstory. Height of the dominant overstory was not necessarily determined by the tallest tree within 200 feet of plot center. Occasionally a lone tree, and this was especially true of Sitka spruce, would extend considerably above the dominant overstory. Such exceptions were ignored, and a tree was selected that represented the height of the generally dominant overstory.

Snag variables were measured as follows:

*Species or at least a category, such as cedar, could usually be determined for a snag, especially if any bark remained. Snags, which could not be positively identified to a category, were recorded as unknown.

*Dbh was measured with a D-tape or a Biltmore stick.

*Soundness was recorded as "sound" (relatively new snag), "firm", "soft", "rotten", "rotten and falling apart", and "shell". Soundness was determined by hacking the snag with a hatchet.

*Condition of the top was either "intact" or "broken".

*Percentage of a snag covered with bark was ocularly estimated.

*Degree of lean from the vertical and height were measured with a Sunnto clinometer.

*Before a limb was counted, it had to be at least 1 inch in diameter at the trunk and over two feet long.

*Distance to the nearest living tree in the dominant canopy and distance to the nearest snag were measured with a Spencer rewinding loggers tape.

*The nearest snag had to be a snag 10 inches or more in dbh and 10 feet or taller.

*Each snag was assigned to one of three possible ages. A recent snag appeared to have died within the last 15 to 20 years, and was mostly bark covered, had an intact top, many limbs, and appeared sound. An old snag was in obvious decay, and a very old snag was in advanced stages of decay and decomposition.

We selected the specific stand to be sampled each day from a Forest Service timber type map. Since we had no familiarity with the area, our choice was random, except of necessity we chose stands near enough to a road that we could reach them in a reasonable time, collect data, and be back at the vehicle in the same day.

Differences between timber stands were evaluated by a randomized block design of the analysis of variance for all 13 variables measured (Steel and Torrie 1960). The species groups or stand classes were assessed by a least squares analysis of variance because of unequal numbers of observations within the classes (Steel and Torrie 1960). Variables which differed between stands at the 0.05 significance level were partitioned by Duncan's new multiple range test (Steel and Torrie 1960: 107-109). This procedure compared each treatment mean with every other stand mean by using a set of significant ranges, rather than a test of two means. Duncan's procedure was favored over the more traditional orthagonal or independent partitions of treatment means because of the lack of information on these forested systems. Such a range test considers the number of treatments in the experiment. A 5 percent protection level, based on the treatment degrees of freedom, was used to guard against declaring false significant differences, for example, finding a significant difference between two stands when none existed (Steel and Torrie 1960).

Relationships between stand, plot, and snag variables were assessed by a correlation analysis (Steel and Torrie 1960). Correlation coefficients, which vary from -1 to +1 (with /1/ representing perfect correlation), were calculated for all combinations of variables; the degree of linear relationship between any two variables was tested at the 0.05 significance level.

Initial efforts to model the environmental system relative to important plot variables were made by using the stepwise analysis of regression procedure (Draper and Smith 1966). Only significant plot variables were subjected to modeling. Basically, the stepwise procedure initially enters into the regression the independent variable most highly correlated with the dependent variable. From the remaining pool of independent variables, the most highly correlated with the response variable (as measured by the partial correlation coefficient) will then enter the model. At each stage of regression, the procedure re-examines (by the partial F statistic) all variables previously incorporated into the model, thus, providing an evaluation of intercorrelation among the independent variables. Therefore, the true contribution of a variable is obtained by examining each variable as if it had been the last to enter the model. A variable which provides a nonsignificant contribution, when the predictive ability of other variables in the model is considered, is removed from the regression. This process is continued until no more variables meets the predetermined significance level to enter the model (P=0.50) and no more variables, which entered the regression are rejected, for example, the best model is obtained.

The predictive ability and usefulness of each model was evaluated by the analysis of regression (F test) and computation of the coefficient of determination R^2 (the percentage of the variation in the dependent variable explained by or accounted for by the independent variables in the model). All statistical analyses were conducted through facilities of the computer center of Louisiana State University, Baton Rouge, using the Statistical Analysis System (SAS) (Barr and Goodnight 1972).

Cavity-Dependent and Cavity-Using Wildlife of Southeast Alaska

Many wildlife species depend upon snags for places to roost, nest, rest, seek shelter, and/or feed. About 85 species of cavity-nesters are among the approximately 800 bird species in the United States. (DeGraaf 1978, Scott and others 1977). In forests of southeastern Alaska, about 27 bird species and 10 mammals plus numerous invertebrates are either cavity-dependent or cavity-using (table 2). The barn swallow (Hirundo rustica), violet-green swallow (Tachycineta thalassina), and tree swallow (Iridoprocne bicolor) formerly required tree cavities or caves, but today they seemingly do quite well nesting under the eves of buildings and even in empty houses. Barn swallows nests were found in storage sheds on the pier at Thorne Bay and under eves in Craig. Unfortunately, most cavity-dependent species are not so adaptable, although some bats have adapted to roosting and having their young in and about buildings.

During summer 1977, the following birds were observed using snags as an elevated site in a clearcut from which to observe intruders or to perch, rest, sing, nest, hunt, or feed.

Goshawk (Accipiter gentilis)
Red-tailed hawk (Buteo jamaicensis)
Bald eagle (Haliaeetus leucocephalus)
Hawk owl (Surnia ulula)
Rufous hummingbird (Selasphorus rufus)
Belted kingfisher (Megaceryle alcyon)
Western flycatcher (Empidonax difficilis)
Tree swallow (Iridoprocne bicolor)
Barn swallow (Hirundo rustica)
Brown creeper (Certhis familiaris)
Winter wren (Troglodytes troglodytes)
American robin (Turdus migratorius)
Hermit thrush (Catharus guttata)
Wilson's warbler (Wilsonia pusilla)
Dark-eyed junco (Junco oreganus)
Yellow-bellied sapsucker (Sphyrapicus varius)
Fox sparrow (Passerella iliaca)
Townsend's warbler (Dendroica townsendi)

The European starling (Sturnus vulgaris) is a cavity-nesting bird, although it will use other sites, that is extending its range into southeastern Alaska. Gibson (1976) saw the bird at Petersburg and Ketchikan in 1976.

Black bear do not require snags in the classical sense, but they use the cave-like hollows that often develop in the elevated root systems of a giant dead hemlock or spruce. A large black bear was flushed during the study from such a resting place. On several occasions places which had been or were being used by bears were observed.

Table 2. Cavity-dependent and cavity-using birds and mammals of southeastern Alaska

Species	Remarks
Common Goldeneye (Bucephala clangula)	See Gibson (1976, p. 24)
Harlequin duck (Histrionicus histrionicus)	Also nest on ground and in holes in cliff.
Common merganser (Mergus merganser)	Also nest on ground under heavy cover and in rock crevices.
American kestrel (Falco sparverious)	...
Screech owl (Otus asio)	...
Great Horned owl (Bubo virginianus)	Old nests of hawks, crows, and others more commonly used.
Hawk owl (Surnia ulula)	...
Saw-whet owl (Aegolius acadicus)	Credited to southeast Alaska by Sweet (1976).
Pigmy owl (Glaucidium gnoma)	...
Vaux's swift (Chaetura vauxi)	...
Common flicker (Colaptes cafer)	...
Yellow-bellied sapsucker (Sphyrapicus varius)	...
Hairy woodpecker (Dendrocopus villosus)	Prefers live trees for nesting but often uses snags.
Downy woodpecker (Dendrocopus pubescens)	...
Northern three-toed woodpecker (Pocoides tridactylus)	...
Western flycatcher (Empidonax difficilis)	Not cavity-dependent, but nests observed in niches of snags.
Barn swallow (Hirundo rustica)	Will use buildings, so no longer cavity-dependent.
Violet-green swallow (Tachycineta thalassina)	Will use buildings, so no longer cavity-dependent.
Tree swallow (Iridoprocne bicolor)	Will use buildings, so no longer cavity-dependent.
Black-capped chickadee (Parus atricapillus)	...
Mountain chickadee (Parus gambeli)	Credited to southeast Alaska by Sweet (1976).
Boreal chickadee (Parus hudsonicus)	Based upon range map in Robbins and others (1966).
Chestnut-backed chickadee (Parus rufescens)	...
Red-breasted nuthatch (Sitla canadensis)	Can excavate but may use old woodpecker holes.
Brown creeper (Certhis familiaris)	Not cavity-dependent but usually nest in cavities or niches of snags.

Species	Remarks
Winter wren (Troglodytes troglodytes)	Commonly nest in cavities of downed trees and limbs no more than a few feet above ground.
Fox sparrow (Passerella iliaca)	Not dependent on cavities but will occasionally nest in a cavity a few feet above ground.
Little brown bat (Myotis lucifugus)	...
Keen's bat (Myotis Keeni)	...
Long legged bat (Myotis volans)	Prefers crevices in rock ledges.
California bat (Myotis californicus)	...
Silver-haired bat (Lasionycteris noctivagans)	...
Big brown bat (Eptesicus fuscus)	Absent or rare in Alexander Archipelago.
Red squirrel (Tamiasciurus hudsonicus)	Absent from much of Alexander Archipelago.
Northern flying squirrel (Glaucomys sabrinus)	...
Raccoon (Procyon lotor)	Released on Prince of Wales Island in 1941.
Pine marten (Martes americana)	Introduced Prince of Wales Island in 1934.

Results

The scheme to abbreviate old-growth types included in the study are described in Table 1.

Snag Density

Snag density varied from 60 per acre in C4 to 8 per acre in S7. Thuja and Chameacyparis were highly decay resistant, which explained the higher number of snags in cedar-stands.

Snag density in hemlock old-growth showed a gradient from H4 through H7. The higher density in H4 was due largely to that type's higher cedar composition. Thirty-two percent of the snags in H4 stands were cedar; in H5 only 7.4 percent were cedar; H6, 3.6 percent; and H7, 1.8 percent cedar. Thuja and Chamaecyparis were far more resistant to decay than hemlock.

Snag density are considerably higher in all forest types studied than the 4.7 an acre reported by Scott (1978) for ponderosa pine (Pinus ponderosa) old-growth types in Arizona. Scott classified a snag as any dead conifer over 7 inches dbh.

Cline (1977) found 7.4 snags an acre in Douglas-fir (Pseudotsuga menziesii) old-growth of Oregon, and Mannan (1977) reported 6.2 snags an acre for an old-growth stand in Oregon. Except for S7, these densities are far below those which occur in old-growth stands of central Prince of Wales Island, Alaska (table 3).

Table 3. Number of snags and living trees per acre by forest type, old-growth stands, Prince of Wales Island, Alaska, 1977.

Stand type	Average number of snags per acre	Number of snags below minimum size per acre 1/	Snags per acre	Number of living trees per acre, 10 inches dbh and greater
H4	25	12	37	44
H5	20	11	31	55
H6	17	9	26	52
H7	13	8	21	45
S7	8	7	15	38
HS5	14	12	26	63
HS6	12	7	19	48
HS7	17	13	30	50
C4	60	20	80	32
ScL	17	22	39	32
ScM	16	18	34	28

1/ Snags less than 10 inches dbh or less the 10 feet tall, except no snag less than 3.5 inches dbh (= 4 inches) was considered.

Species Composition of Snags in Old-Growth Stands

Snags in hemlock old-growth were predominantly hemlock: 79.7 percent for H5 and 79 percent for H6 and 87.8 percent for H7. The exception was H4 where 45.2 percent were hemlock. In S7 snags were 30 percent hemlock and 45 percent Sitka spruce plus 25 percent unknowns. Sitka spruce matures in about 500 years, but unusually large trees may be 700 to 800 years old. Western hemlock seldom attains an age over 500 years. Consequently, Sitka spruce is longer lived than western hemlock (Harlow and Harrar 1969). Since Sitka spruce may live 200 to 300 years longer than western hemlock, a relatively high percentage of western hemlock snags in a large, old stand such as S7 is not surprising. The stand probably began as hemlock-spruce, spruce out lived the hemlock, and hemlock became snags at a faster rate than Sitka spruce.

Hemlock-spruce stands have practically all hemlock-spruce snags. However, hemlock types have some Sitka spruce and cedar snags. Snags of hemlock, Sitka spruce, western redcedar, Alaska-cedar, and lodgepole pine were in ScL and ScM. On Prince of Wales Island, and probably throughout the archipelago, lodgepole pine occurs only in ScL and ScM.

Unknown snags vary from 6.5 to 39.67 percent depending upon old-growth type. Unknowns were snags, usually well decomposed with no bark or limbs, which could not be accurately assigned to a species, genus, or category. Nevertheless, all the unknowns were either western hemlock, mountain hemlock, Sitka spruce, western redcedar, Alaska cedar, or lodgepole pine (table 4). When cedar could not be identified as Thuja or Chamaecyparis it is called cedar.

Table 4. Snag composition in 11 old-growth forest types, Prince of Wales Island, Alaska, 1977.

Stand type	Snag Classification Categories									Snags per acre
	Western hemlock	Hemlock 1/	Mountain hemlock	Western redcedar	Alaska cedar	Cedar 2/	Sitka spruce	Lodgepole pine	Unknown	
	Percentage									Number
H4	12.3	32.0	0.9	4.7	17.9	9.4	1.9	--	20.8	35
H5	72.9	6.8	--	6.2	0.6	0.6	4.5	--	8.5	20
H6	74.5	4.5	--	1.8	--	1.8	3.6	--	13.6	17
H7	76.8	11.1	--	0.9	--	0.9	3.7	--	6.5	13
S7	30.0	--	--	--	--	--	45.0	--	25.0	8
HS5	63.1	--	--	--	--	--	23.7	--	13.2	14
HS6	65.2	0.8	--	0.8	--	--	7.6	--	25.4	12
HS7	76.6	--	--	--	--	--	10.3	--	13.1	17
C4	--	--	--	20.8	8.3	45.8	4.2	--	20.8	60
ScL	2.0	8.8	2.0	12.7	21.6	15.7	5.9	7.8	23.5	17
ScM	14.3	11.0	--	3.3	19.8	7.7	2.2	2.2	39.6	16

1/ Tsuga.

2/ Thuja and Chamaecyparis.

Average Plot and Snag Variables

Averages for some plot variables are presented in Table 5. Means for selected snag variables appear in Table 6.

Average plot variables are of little value except to illustrate by presenting standard deviations and ranges, the extreme variability that existed among plots in the sample. Stand types ScL, ScM, and C4 are not commercial forest types. Basal area/acre is significantly less in C4, ScL, and ScM than in any commerical forest type (table 7). However, values from C4, ScL, and ScM were included in computing mean plot and mean snag variables.

The mean distance between snags throughout old-growth types on Prince of Wales Island is 22.4 feet. It is possible, using the nearest neighbor method of phytosociological sampling, described by Cottam and Curtis (1956) and Cottam and others (1953) to estimate the average number of snags per acre on Prince of Wales Island. The nearest neighbor distance is the average distance from each individual in the population to its closest neighbor. Clark and Evans (1954) showed that, in a randomly distributed population, the distance between nearest neighbors is equal to one-half the square root of the mean area. Distances were measured more in the way recommended by Clark and Evans (1954) than the point method of Cottam and Curtis (1956), so no correction factor is neccessary.

A rough estimate of 21.7 snags an acre for forested land on Prince of Wales Island demonstrates the millions of snags present. The 10,000 acres of old-growth clearcut annually in the Ketchikan area represents a removal of at least 217,000 snags, and this removal is likely permanent since few snags will develop in the 100-150 year rotation hoped for by foresters.

If a tree to be felled might strike a snag, then under Alaskan law the snag must be felled first. Under this statute, no snags may be left standing where clearcutting is practiced. In none of the eight commercial forest types studied did the average distance from a snag to the closest living tree in the dominant canopy exceed 16 feet. The maximum such distance recorded (N = 1,003), even including the relatively open ScL and ScM, was 45 feet.

Even if the law is amended or rescinded, simply leaving snags in a clearcut is a short-term proposition, because snags rot away, fall down, or are windthrown. There must be a constant supply of fresh snags entering the snag population, or eventually there will be no snags.

Table 5. Averages for some plot variables, snag sampling in old-growth stands, Prince of Wales Island, Alaska, 1977.

Plot Variable	Number	Mean	Standard deviation	Range
Elevation (feet)	250	353.4	291.1	0 - 1250
Slope (degrees)	314	23.7	20.3	0 - 80
Basal Area (square feet per acre)	314	121.0	44.4	0 - 230
Crown Density (percentage)	315	66.6	25.7	0 - 99
Height of dominant canopy (feet)	311	114.9	39.6	28 - 211

Table 6. Averages for various snag variables, old-growth forest, Prince of Wales Island, Alaska, 1977.

Variable	Number	Mean	Standard deviation	Range
dbh (inches)	1,003	23.6	11.2	10 - 91
Soundness	1,002	2.5	1.4	0 - 5
Condition of the top	1,003	1.2	0.4	1 - 2
Percentage covered by bark	1,002	47.3	43.0	0 -100
Lean from the vertical (degrees)	1,001	2.1	6.4	0 - 65
Number of limbs	1,003	15.0	29.0	0 - 99
Percentage extending above the dominant canopy	1,003	2.0	9.1	0 - 96
Distance to the nearest living tree in the dominant overstory (feet)	1,003	11.9	8.0	0 - 45
Distance to the nearest snag (feet)	1,003	22.4	15.9	0 -112
Number of natural cavities	1,003	0.06	0.6	0 - 15
Number of animal-made cavities	1,003	0.06	0.5	0 - 8
Age	1,002	2.4	0.7	0 - 3
Height (feet)	1,003	46.0	33.2	10 -179

Table 7. Means for plot variables by old-growth forest type, Prince of Wales Island, Alaska, 1977. 1/

Stand type	Elevation	Slope	Basal area per acre	Crown density	Snags per 0.2-acre plot	Height of the dominant overstory	Snags below minimum per 0.2-acre plot	Number of trees 10" dbh + per 0.2-acre
	Feet	Degree	Sq. feet	Percent	Number		Number	Number
H4	635 (16)A	22 (21) B	123 (21)A	64 (21) D	5.0 (21) B	95 (20) D	2.5 (20) B	8.9 (16)
H5	524 (32)A	27 (45) B	145 (45)A	78 (45)ABC	3.9 (45) C	113 (45) C	2.3 (45) B	11.0 (36)A
H6	691 (36)A	34 (33)AB	137 (33)A	74 (33) BC	3.3 (33) CD	131 (32) B	1.8 (33) B	10.3 (33)A
H7	262 (43) B	35 (43)A	131 (42)A	72 (43) CD	2.5 (43) DE	140 (42)AB	1.7 (43) B	9.0 (18)
S7	000 (14) D	0 (14) C	138 (14)A	48 (14) E	1.4 (14) E	150 (14)A	1.4 (14) B	7.6 (14)
HS5	000 (14) D	1 (14) C	137 (14)A	70 (14) CD	2.7 (14) CDE	106 (14) CD	2.4 (14) B	12.6 (14)A
HS6	23 (16) D	26 (51) B	128 (51)A	80 (51)AB	2.4 (51) DE	138 (51)AB	1.4 (51) B	9.7 (51)
HS7	162 (31) C	35 (31)AB	138 (31)A	87 (31)A	3.4 (31) CD	144 (31)AB	2.5 (31) B	9.9 (30)
C4	750 (2)A	35 (2)AB	92 (2)AB	50 (2) DE	12.0 (2)A	95 (2) CD	4.0 (2)AB	6.5 (2)
ScL	470 (31)A	11 (31) BC	76 (31) B	29 (31) E	3.3 (31) CD	56 (31) E	4.5 (31)A	6.4 (30)
ScM	325 (18) B	11 (29) BC	60 (30) B	36 (30) E	3.0 (30) CD	58 (29) E	3.7 (30)AB	5.6 (18)

1/ The first number of each entry is the mean value for the variable, the number in parentheses is the sample size, and means in any column with the same letter are not significantly different at alpha level = 0.05

Natural and Animal-made Cavities

A natural cavity was defined as any snag cavity caused by other than an animal, which might offer refuge or a nesting site to a cavity-dependent or cavity-using vertebrate species. All animal-made cavities observed were woodpecker holes (based upon size and "roundness" of the hole), and most, if not all, of these were made by yellow-bellied sapsuckers. Sapsuckers may use the same snag for nesting year after year, but a new cavity is excavated each year (Scott and others 1977).

A random sample of 1,002 snags of ~~six~~ species over a wide area of central Prince of Wales Island were examined. Only 2.1 percent had one or more animal-made cavities. The list of cavity-dependent and cavity-using vertebrates in Table 2 consists of 27 birds and 10 mammals. During 72 days afield (June 3, 1977, to August 17, 1977, except for July 1-4) on central Prince of Wales Island, only 13 of the birds and none of the mammals were observed. The birds observed were the sparrow hawk, hawk owl, pigmy owl, common flicker, yellow-bellied sapsucker, hairy woodpecker, western flycatcher, barn swallow, tree swallow, chestnut-backed chickadee, brown creeper, winter wren, and fox sparrow.

Gibson (1977) conducted an extensive bird species/habitat survey in the Alexander Archipelago from June 4 to August 1, 1975. He observed only 12 of the birds listed in Table 2. Gibson did not see a sparrow hawk, none of the owls, downy woodpecker, northern three-toed woodpecker, violet-green swallow (he observed two near the Juneau Airport), black-capped chickadee, mountain chickadee, boreal chickadee, nor red-breasted nuthatch. Field work is badly needed in the archipelago and on the mainland to ascertain the density and range of cavity-dependent and cavity-using wildlife.

It was often difficult to determine that no animal-made cavity existed in a snag. Some snags were over 100 feet tall, and the average height was 46 feet (Standard deviation = 33.2 feet, range = 10 - 179 feet, number = 1,003). Each snag was checked as closely as possible, and few, if any, animal-made cavities were missed.

Natural cavities occurred in 3.4 percent of the snags. A snag with its top broken out may develop a vertical cavity at the top. These cavities are not always apparent to observers on the ground. Such cavities are used for nesting by some owls and the common goldeneye, and as a den or roosting place by bats and raccoons.

Animal-made cavities occurred in 4.6 percent of Sitka spruce snags and 3.3 percent of hemlock snags, while natural cavities occurred in only 1.5 percent of Sitka spruce snags, but they occurred in 3.7 percent of hemlock snags (table 8).

The average number of animal-made cavities per snag varied from 0 in mountain hemlock, Alaska-cedar, lodgepole pine, and cedar to 0.17 in Sitka spruce. However, there was no significant difference in the mean number of animal-made cavities per snag for any of the species (table 9). The mean for natural cavities per snag varied from 0 to 0.12 depending upon the species, but none of these differences were significant (table 10).

The average for animal-made cavities per snag by forest type varied from 0 in timber types C4, HS5, H6, and S7 to 0.15 in HS7, but no differences among forest types were significant (table 11). The average of natural cavities per snag by forest type ranged from 0 in C4 and S7 to 0.16 in ScL, but no old-growth forest type was significantly different from another in this regard (table 12). The percentage of snags with natural cavities and animal-made cavities in old-growth forest types is shown in Table 13.

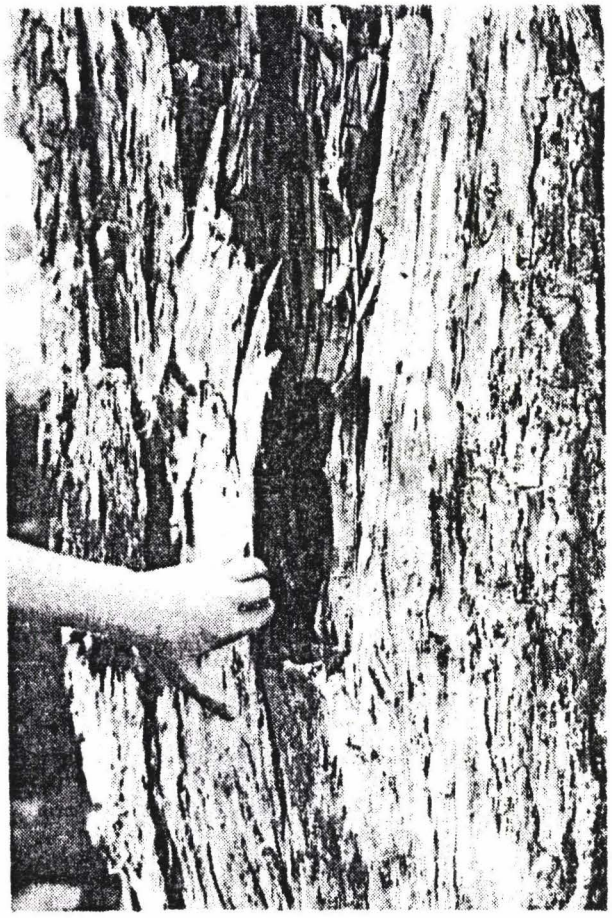

Figure 2. A natural cavity in a snag. Natural cavities occur in 3.4 percent of the snags in old-growth forests of Prince of Wales Island, Alaska, July 1977.

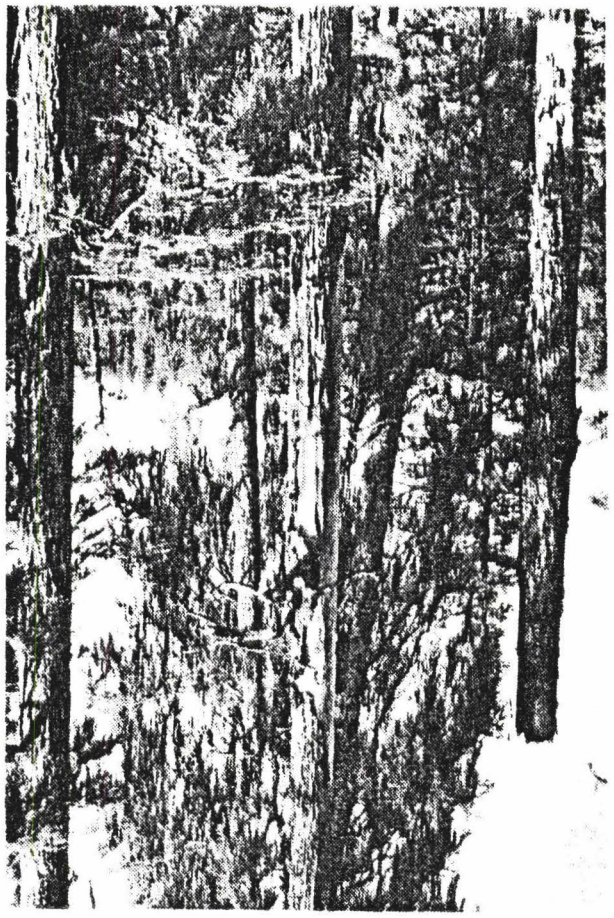

Figure 3. Animal-made cavities occur in 2.1 percent of the snags in old-growth forests of Prince of Wales Island, Alaska, July 1977. These holes were made by the yellow-bellied sapsucker.

Table 8. Percentage of snags with natural cavities and animal-made cavities by species, old-growth forests, Prince of Wales Island, Alaska. 1977.

Species	No. snags examined	Snags with animal-made cavities	Avg. animal-made cavities per snag with animal-made cavities	Snags with natural cavities	Avg. natural cavities per snag with cavities
	Number	Percentage	Number	Percent	Number
Western hemlock	516	2.1	2.5	3.7	1.6
Sitka spruce	65	4.6	3.7	1.5	1.0
Hemlock	83	1.2	3.0	0	---
Western redcedar	36	2.8	2.0	5.6	1.5
Unknown	179	2.8	2.8	3.9	3.1
Mountain hemlock	3	0	0	0	---
Alaska-cedar	62	0	0	6.4	1.0
Lodgepole pine	10	0	0	0	---
Cedar	48	0	0	2.1	1.0

Table 9. Duncan's multiple range test for the variable "number of animal-made cavities per snag", by species, old growth forests, Prince of Wales Island, Alaska, 1977. 1/

Species	Number	Mean number of animal-made cavities per snag
Sitka Spruce	65	0.17
Unknown	179	0.08
Western redcedar	36	0.06
Western hemlock	516	0.05
Hemlock	83	0.04
Mountain hemlock	3	0.00
Alaska cedar	62	0.00
Lodgepole pine	10	0.00
Cedar	48	0.00

1/ Means are not significantly different at alpha level = 0.05.

Table 10. Duncan's mulitple range test for the variable "number of natural cavities per snag", by species, old-growth forests, Prince of Wales Island, Alaska. 1977. 1/

Species	Number	Mean number of natural cavities per snag
Unknown	179	0.12
Western redcedar	36	0.08
Alaska-cedar	62	0.06
Western hemlock	516	0.06
Cedar	48	0.02
Mountain hemlock	3	0.00
Hemlock	83	0.00
Lodgepole pine	10	0.00

1/ Means are not significantly different at alpha level = 0.05.

Table 11. Duncan's multiple range test for the variable "number of animal-made cavities per snag", old-growth forest type, Prince of Wales Island, Alaska, 1977. 1/

Stand Type	Number	Mean number of animal-made cavities per snag
HS7	107	0.15
H7	108	0.14
ScM	91	0.11
HS6	120	0.07
ScL	102	0.06
H5	177	0.01
H4	106	0.01
HS5	38	0.00
C4	24	0.00
H6	110	0.00
S7	20	0.00

1/ Means are not significantly different at alpha level = 0.05.

Table 12. Duncan's multiple range test for the variable "number of natural cavities per snag", old-growth forest types, Prince of Wales Island, Alaska, 1977. 1/

Stand Type	Number	Mean number of natural cavities per snag
ScL	102	0.16
ScM	91	0.09
HS5	38	0.08
H7	108	0.07
HS6	120	0.06
H6	110	0.05
HS7	107	0.05
H4	106	0.04
H5	177	0.02
C4	24	0.00
S7	20	0.00

1/ Means are not significantly different at alpha level = 0.05.

Table 13. Percentage of snags with natural and animal-made cavities by old-growth forest type, Prince of Wales Island, Alaska. 1977

Stand Type	Number of snags examined	Percentage of snags with at least one animal-made cavity	Percentage of snags with at least one natural cavity
H4	106	0.9	3.8
H5	177	0.6	1.7
H6	110	0.0	3.6
H7	108	4.6	2.8
S7	20	0.0	0.0
HS5	38	0.0	7.9
HS6	120	2.5	5.0
HS7	107	5.6	2.8
C4	24	0.0	0.0
ScL	102	1.0	2.0
ScM	91	4.4	6.6

Snags Extending Above The Dominant Canopy

Snags extending above the dominant canopy could be important perch-sites for hawks, owls, swallows, flycatchers, eagles, and other birds. They might be targets for lightning strikes and, thereby, offer a potential fire hazard. Fire is not a common occurrence in old-growth stands of southeastern Alaska, but it can pose a problem in clearcuts during prolonged droughts. Such fires are usually man-caused, because lightning is uncommon in the region.

About one-fourth of snags in noncommerical forest studied (C4, ScL, ScM) were taller than the dominant canopy. In commercial old-growth no snags in S7 were taller than the dominant trees, only 0.9 percent in HS7 and H7 while the value varied from 3.3 percent in HS6 to 6.8 percent in H5 (table 14).

Snags in ScL averaged 33.6 percent taller than the canopy (32.2 percent in ScM). In commercial forests the value ranged from 0 percent in S7 to 19.3 percent in H5.

Among the stand classes a higher percentage of Alaska-cedar (30.6 percent) snags are taller than the surrounding canopy than in any other group (mountain hemlock is excluded because of the small sample size) (table 15). This is due largely to the durability of Alaska-cedar wood. Alaska-cedar snags remain intact in the top much longer than other species.

The average percentage of a snag extending above the canopy varied from 0 percent in lodgepole pine to 9.0 percent in cedar. There was no significant difference in this value among cedar, Alaska-cedar, and western redcedar. However, there was a significant difference between these groups and hemlock, Sitka spruce, unknown, western hemlock and lodgepole pine, but no significant difference among the second listed group (table 16). These data, too, illustrate the durability of western redcedar and Alaska-cedar snags.

The mean percentages of a snag's height above the canopy varied from 0 percent in S7 to 8.6 percent in ScL. In this regard only ScL and ScM were significantly different from the other forest types studied (except for C4, see table 17).

Table 14. Percentage of snags extending above the dominant canopy and the average percentage of a snag's height extending above the dominant canopy by old-growth forest type, Prince of Wales Island, Alaska, 1977.

Stand type	Number of examined	Percentages of all snags extending at least a portion of it's height above the dominant canopy	Avg. percentage of a snag's height extending above the dominant canopy
H4	106	5.7	14.0
H5	177	6.8	19.3
H6	110	3.6	8.5
H7	108	0.9	2.0
S7	20	0.0	0.0
HS5	38	5.3	7.0
HS6	120	3.3	10.0
HS7	107	0.9	7.0
C4	24	25.0	16.5
ScL	102	25.5	33.6
ScM	91	22.0	32.2

Table 15. Percentage of snags extending above the canopy and the average percentage of a snag's height extending above the canopy, by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

Species	Number of snags examined	Percentage of these snags extending above the dominant canopy	Avg. percentage of a snag's height extending above the dominant canopy
Western hemlock	516	3.7	16.4
Sitka spruce	65	10.8	14.0
Mountain hemlock	3	33.3	23.0
Hemlock	83	7.2	23.2
Western redcedar	36	16.7	46.5
Alaska-cedar	62	30.6	25.7
Lodgepole pine	10	0.0	0.0
Unknown	179	6.1	23.4
Cedar	48	27.1	33.3

Table 16. Duncan's multiple range test for the variable "percentage of snag extending above the canopy" by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

Species	Number	Mean percentage of the snag extending above dominant canopy	Means with the same letter are not significantly different at alpha level = 0.05
Cedar	48	9.0	A
Alaska-cedar	62	7.9	A
Western redcedar	36	7.8	A
Mountain hemlock	3	7.7	A B
Hemlock	83	1.7	B
Sitka spruce	65	1.5	B
Unknown	179	1.4	B
Western hemlock	516	0.6	B
Lodgepole pine	10	0.0	B

Table 17. Duncan's multiple range test for the variable "percentage of snag's height extending above the canopy", by old-growth forest types, Prince of Wales Island, Alaska, 1977.

Stand Type	Number	Mean percentage of snags above the dominant canopy	Means with the same letter are not significantly different at alpha level = 0.05
ScL	102	8.6	A
ScM	91	7.1	A
C4	24	4.1	A B
H5	177	1.3	B
H4	106	0.8	B
HS5	38	0.4	B
HS6	120	0.3	B
H6	110	0.3	B
HS7	107	0.1	B
H7	108	<0.1	B
S7	20	0.0	B

Limbs on Snags

Whether a snag has limbs and the number of limbs depends upon its age and genus. The younger a snag the more limbs it will have, and Alaska-cedar and western redcedar retain limbs longer than Sitka spruce, hemlock, and lodgepole pine. Limbs provide many birds a perch for hunting, resting, and feeding. Use of a snag by some species may depend upon presence of limbs.

The sample consisted of 1,003 snags of which 51.6 percent had no limbs, 40.5 percent had 1 to 99 limbs, and 7.9 percent had more than 99 limbs.

The mean number of limbs per snag was highest in Alaska-cedar, 30.7 percent (mountain hemlock ignored due to small sample size); and lowest in unknown snags, 1.2 (table 18). "Unknowns" are snags that could not be identified, due to advanced stage of decomposition, which explains the low average number of limbs per snag in the unknown category. Unknown snags differed significantly in the mean number of limbs per snag from Alaska-cedar and cedar, but no other differences in this variable were significant among the species (table 18).

Mean number of limbs per snag varied from 8.5 in H7 to 34.2 in C4. In addition, the 18.5 in HS6 was significantly different from C4 and H7, but no other differences were significant (table 19).

Table 18. Duncan's multiple range test for the variable "number of limbs per snag" by species, Prince of Wales Island, Alaska, 1977.

Species	Number	Mean number of limbs per snag 1/	Means with the same letter are not significantly different at alpha level = 0.05
Mountain hemlock	3	48.0	A
Alaska-cedar	63	30.7	A
Cedar	48	28.6	A
Lodgepole pine	10	20.7	A B
Western redcedar	36	20.1	A B
Sitka spruce	65	16.6	A B
Western hemlock	516	15.7	A B
Hemlock	83	14.4	A B
Unknown	179	1.2	B

1/ Snags with more than 99 limbs were recorded only as "99". Only 7.9% of the snags had more than 99 limbs.

Table 19. Duncan's multiple range test for the variable "number of limbs per snag" by old-growth forest type, Prince of Wales Island, Alaska, 1977.

Stand type	Number	Mean number of limbs per snag 1/	Means with the same letter are not significantly different at alpha level = 0.05
C4	24	34.2	A
HS6	120	18.5	B
ScL	102	17.7	B C
H5	177	17.4	B C
H4	106	15.4	B C
H6	110	12.7	B C
ScM	91	12.6	B C
HS7	107	12.4	B C
S7	20	12.1	B C
HS5	38	9.1	B C
H7	108	8.5	C

1/ Snags with more than 99 limbs were recorded only as "99". Only 7.9% of the snags had more than 99 limbs.

Snag Diameter

Snag dbh varied from the 10 inch minimum up to 91 inches in a Sitka spruce. The mean was 23.6 inches (Standard deviation = 11.2, Number = 1,003), but, by species, mean dbh ranged from 13.1 inches in lodgepole pine to 29.4 inches for Sitka spruce. The differences between the mean dbh for Sitka spruce and that of western hemlock was significant, and the average dbh for snags of these species also differed significantly from those of the other seven groups. Other significant differences also existed among the species regarding snag dbh (table 20).

Snags in S7 had a larger mean dbh (38.1 inches) than did those in the other 10 forest types. Snag dbh in HS6, H6, HS7, H7, and HS5 were not significantly different from one another. ScL snags were significantly smaller than those in other forest types (table 21).

Table 20. Duncan's multiple range test for the variable "snag dbh" by species, of old-growth forests, Prince of Wales Island, Alaska, 1977.

Species	Number	Mean dbh (inches)	Means with the same letter are not significantly different at alpha level = 0.05
Sitka spruce	65	29.4	A
Western hemlock	516	25.3	B
Unknown	179	22.8	C
Hemlock	83	21.1	C D
Western redcedar	36	20.5	C D E
Cedar	48	18.6	D E
Alaska-cedar	62	16.7	E
Mountain hemlock	3	15.0	E
Lodgepole pine	10	13.1	E

Table 21. Duncan's multiple range test for the variable "snag dbh" by old-growth forest type, Prince of Wales Island, Alaska, 1977.

Stand type	Number	Mean dbh (inches)	Means with the same letter are not significantly different at alpha level = 0.05
S7	20	38.1	A
HS6	120	28.0	B
H6	110	27.5	B
HS7	107	27.4	B
H7	108	27.3	B
HS5	38	24.2	B C
H5	177	23.9	C
C4	24	20.3	C D
H4	106	19.4	D
ScM	91	16.3	D E
ScL	102	14.2	E

Snag Height

Mean snag height among species was lowest among unknown snags (28.6 feet) and highest in mountain hemlock (57.0 feet) and cedar (54.9 feet), but none of these were significant (table 22). Snags in S7 averaged 36 feet high, and those in C4 averaged 57 feet while the other types showed some mean between these two extremes (table 23). None of these differences was significant leading one to conclude that average snag height is the same regardless of old-growth forest type.

Table 22. Duncan's multiple range test for the variable "snag height" by species, old-growth forests, Prince of Wales Island, Alaska, 1977. 1/

Species	Number	Mean height (feet)
Mountain hemlock	3	57.0
Cedar	48	54.9
Western redcedar	36	53.5
Alaska-cedar	62	52.2
Sitka spruce	65	51.7
Western Hemlock	516	49.2
Hemlock	83	45.7
Lodgepole pine	10	43.6
Unknown	179	28.6

1/ Means are not significantly different at alpha level = 0.05.

Table 23. Duncan's multiple range test for the variable "snag height" by old-growth forest type, Prince of Wales Island, Alaska, 1977. 1/

Stand type	Number	Mean height (feet)
C4	24	57
HS6	120	51
H6	110	49
H7	108	48
H5	177	48
HS7	107	45
H4	106	45
ScL	102	44
ScM	91	39
HS5	38	36
S7	20	36

1/ Means are not significantly different at alpha level = 0.05.

Lean in Snags

Whether a snag is used by some wildlife species might depend upon the snag's lean. A severely leaning snag (40°+) might not be acceptable since rain could enter a cavity on the upper side and eggs and/or young could fall from a cavity on the lower side. In contrast, black bear, racoon, owls, and other wildlife may prefer a strongly leaning snag for feeding, resting, or hunting.

Snag lean in an old-growth forest is important to know because snags left in clearcuts often show a far more pronounced lean than occurs in old-growth stands. Failure of certain wildlife species to use snags left in clearcuts might result from the frequent excessive lean of such exposed snags. Nothing, is known about the effect, if any, of snag lean on wildlife usage of snags in southeastern Alaska. Yet it is something that must be determined before snags can be truthfully managed under a scheme of intensive silviculture.

Snags in old-growth forests of central Prince of Wales Island do not show a pronounced lean. Generally snags stand straight and seem well-anchored. The average lean for 1,001 snags was 2.1° (Standard deviation = 6.4, range = 0° to 65°). Snags in C4 shows the greatest average lean (7.3°), and this value was significantly higher than that calculated for any other forest type. Snags in H6 had the low average lean (0.6°), but this was not significantly different from that calculated for S7 (2.6°) and five other old-growth forest types (table 24).

Western redcedar snags had the highest average lean (5.4°), but this was not significantly different from the average lean in Alaska-cedar (4.2°), unknown snags (3.3°), and cedar (3.0°). Other differences in average lean by species were significant (table 25).

Table 24. Duncan's multiple range test for the variable "snag lean" by old-growth forest type, Prince of Wales Island, Alaska, 1977.

Stand Type	Number	Mean lean from vertical in degrees	Means with the same letter are not significantly different at alpha level = 0.05
C4	24	7.3	A
ScM	91	3.6	B
H4	106	3.6	B
ScL	102	3.4	B
S7	19	2.6	B C
HS5	37	1.9	B C
H5	177	1.8	C
HS7	107	1.4	C
H7	108	1.1	C
HS6	120	0.7	C
H6	110	0.6	C

Table 25. Duncan's multiple range test for the variable "snag lean" by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

Species	Number	Mean degree of lean from vertical	Means with the same letter are not significantly different at alpha level = 0.05
Western redcedar	36	5.4	A
Alaska-cedar	62	4.2	A B
Unknown	178	3.3	A B
Cedar	48	3.0	A B C
Hemlock	83	2.3	B C
Mountain hemlock	3	1.7	B C
Western hemlock	515	1.2	C
Sitka spruce	65	1.0	C
Lodgepole pine	10	0.9	C

Snag Age and Soundness

Scott (1978) used a seemingly accurate, albeit time consuming, method to determine snag age in old-growth ponderosa pine. However, we did not use that method due to time and personnel limitations so snag age was estimated in a crude manner. Based upon snag appearance (and before chopping with a hatchet to assign soundness), a snag was assigned one of three possible ages: recent, old, or very old.

Snag age, depending upon the species, is related to snag soundness, and snag soundness can be important to wildlife. Thomas and others (1976) point out that cavity-users either excavate cavities or occupy existing cavities. Of the excavators some excavate in sound wood and others in soft wood. Those species which occupy existing cavities may use one made by an excavator, or they might occupy a natural cavity created by decay. Obviously, the use of a snag by any one of these groups or subgroups depends upon its soundness. If snag management is to cater to all cavity-users, snags must be available in all states of soundness.

There was no significant difference in the average age of snags among the 11 old-growth forest types studied. Predictably, snags in an old-growth forest are of all ages and, therefore, of all levels of soundness (table 26). However, average ages of different species did differ significantly (table 27). Unknown snag mean age of 2.94 was higher than that of all other species. Alaska-cedar's mean age (2.04) was lower than that of Sitka spruce (2.39) and western redcedar (2.39), but no other significant differences existed in average snag age among species. The age of Alaska-cedar could have been consistently underestimated because of the extreme durability of the tree following death.

The average soundness of unknown snags was 1.6, significantly lower than the mean soundness of any other snag except mountain hemlock. No significant difference existed in the mean soundness for snags of other species (table 28). Average soundness of snags in S7, HS5 and HS7 was significantly less then that for snags in other forest types except HS6 and H6 (table 29).

Table 26. Duncan's multiple range test for the variable "snag age" by old-growth forest type, Prince of Wales Island, Alaska, 1977. 1/

Stand Type	Number	Mean Age 2/
S7	20	2.5
HS5	38	2.5
ScM	91	2.5
H4	106	2.4
HS7	107	2.4
ScL	102	2.4
H6	110	2.4
HS6	120	2.3
H7	107	2.3
H5	177	2.2
C4	24	2.1

1/ Means are not significantly different at alpha level = 0.05.

2/ Possibilities and their assigned values were recent, 1; old, 2; and very old, 3. Therefore, the higher this number the greater the age.

Table 27. Duncan's multiple range test for the variable "snag age" by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

Species	Number	Mean age 1/	Means with the same letter are not significantly different at alpha level = 0.05
Unknown	179	2.94	A
Sitka spruce	64	2.39	B
Western redcedar	36	2.39	B
Mountain hemlock	3	2.33	B C
Lodgepole pine	10	2.30	B C
Cedar	48	2.29	B C
Hemlock	83	2.25	B C
Western hemlock	516	2.20	B C
Alaska-cedar	62	2.04	C

1/ Higher the value, greater the age (Categories were recent, 1; old, 2; and very old, 3).

Table 28. Duncan's muliple range test for the variable "snag soundness" by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

Species	Number	Mean soundness of the snags 1/	Means with the same letter are not significantly different at alpha level = 0.05
Lodgepole pine	10	3.2	A
Alaska-cedar	62	3.2	A
Cedar	48	3.1	A
Western redcedar	36	3.1	A
Western hemlock	516	2.6	A
Hemlock	83	2.5	A
Sitka spruce	65	2.2	A
Mountain hemlock	3	1.7	A B
Unknown	178	1.6	B

1/ Higher the value, greater the soundness. Maximum possible value was 5 (sound) while the lowest possible value was 0 (shell).

Table 29. Duncan's multiple range test for the variable "snag soundness" by old-growth forest type, Prince of Wales Island, Alaska, 1977.

Stand type	Number	Mean soundness of the snags 1/	Means with the same letter are not significantly different at alpha level = 0.05
C4	24	3.0	A
ScL	102	2.8	A
H7	108	2.8	A
ScM	91	2.6	A
H4	106	2.5	A
H5	176	2.5	A
HS6	120	2.4	A B
H6	110	2.3	A B
HS7	107	2.1	B
HS5	38	1.9	B
S7	20	1.8	B

1/ Higher the vaule, greater the soundness. Maximum possible value was 5 ("sound") while the lowest possible value was 0 (a "shell").

Percentage of A Snag Covered by Bark

This variable, too, is partly a product of snag age, but species play a part. Scott (1978) said, "Bark retains moisture in the sapwood of snags and probably improves conditions for those birds that make their own holes". As bark lossens and begins to fall, foraging becomes easier for some species like the brown creeper. The brown creeper also nests behind pieces of bark that curl out from the tree (DeGraaf 1978). Once a snag has lost its bark, it becomes more attractive to some woodpeckers. Snags in old-growth stands are available in all stages of bark covering. The mean for all snags in the study was 74.3 percent (Standard deviation = 43 percent, range = 0 percent to 100 percent, Number = 1,002).

Western hemlock (64.4 percent) and hemlock (59.5 percent) had significantly higher mean values than any other species. Unknown snags (0.9 percent) was significantly lower than all other species except mountain hemlock (small sample). No other significant differences existed in this variable among the species (Table 30).

Snags in C4 averaged 60.5 percent bark covering, but this value was not significantly different from those observed for snags in H4, H5, H6, H7, HS6, or HS7. Significant differences do exist for this variable among forest types (table 31).

Table 30. Duncan's multiple range test for variable "percentage of a snag covered by bark" by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

Species	Number	Mean percentage of snag covered by bark	Means with the same letter are not significantly different at alpha level = 0.05
Western hemlock	515	64.4	A
Hemlock	83	59.5	A
Alaska-cedar	62	44.4	B
Lodgepole pine	10	43.2	B
Cedar	48	41.8	B
Sitka spruce	65	37.6	B
Western redcedar	36	35.7	B
Mountain hemlock	3	35.0	B C
Unknown	179	0.9	C

Table 31. Duncan's multiple range test for the variable "percentage of a snag covered by bark" by old-growth forest type, Prince of Wales Island, Alaska, 1977.

Stand type	Number	Mean percentage of snag covered by bark	Means with the same letter are not significently different at alpha level = 0.05
C4	24	60.5	A
H7	108	60.1	A
H5	177	58.1	A
H6	110	51.7	A
HS6	120	50.6	A
HS7	106	46.6	A B
H4	106	39.2	A B C
ScL	102	35.3	B C
S7	20	34.4	B C
HS5	38	33.4	B C
ScM	91	30.0	C

Condition of A Snag's Top

A top was either "intact" or "broken out". Data by species and forest types are presented in Tables 32 and 33.

Distance From A Snag To the Nearest Overstory Tree

Distance from a snag to the nearest overstory tree shows the degree to which snags are surrounded by the living stand. Some wildlife species prefer snags uncrowded by the overstory, such as the hairy woodpecker, while others may show a preference for snags closely surrounded by living trees. This is another facet of snag use by wildlife about which apparently nothing is known for southeast Alaska.

The average distance from a snag to the nearest living overstory tree was 11.9 feet, (Standard deviation = 8.0 feet, range = 0 to 45 feet, number = 1,003). The mean distance was lowest in ScL (8.5 feet) and highest in S7 (15.2 feet). Average figures presented in Tables 34 and 35 demonstrate that old-growth snags are generally well crowded by overstory trees. These data prove that the Alaska law requiring the removal of any snag that might be hit by a felled tree precludes leaving any snags in clearcuts of central Prince of Wales Island and probably throughout the Alexander Archipelago.

A positive correlation ($R = 0.12$, $P \leq .002$, $N = 1,003$) between the number of natural cavities in a snag and the distance to the nearest living tree was found. The correlation for the number of animal-made cavities was not significant ($R = -.01$, $P \leq 0.7587$, $N = 1,003$).

Table 32. Duncan's multiple range test for the variable "condition of snag's top" by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

Species	Number	Mean condition of the top 1/	Means with the same letter are not significantly different at alpha level = 0.05
Mountain hemlock	3	1.67	A
Alaska-cedar	62	1.60	A
Cedar	48	1.54	A
Western redcedar	36	1.47	A
Lodgepole pine	10	1.30	A B
Hemlock	83	1.24	A B
Sitka spruce	65	1.23	A B
Western hemlock	516	1.17	A B
Unknown	179	1.11	B

1/ Possibilities were "broken out", 1; or "intact", 2.

Table 33. Duncan's miltiple range test for the variable "condition of snag's top" by old-growth forest type, Prince of Wales Island, Alaska, 1977.

Stand type	Number	Mean condition of the top 1/	Means with the same letter are not significantly different at alpha level = 0.05
ScL	102	1.53	A
C4	24	1.50	A B
ScM	91	1.34	B C
H4	106	1.27	C D
HS6	120	1.20	D E
H5	177	1.96	D E
HS5	38	1.16	D E
HS7	107	1.13	E
H7	108	1.10	E
S7	20	1.10	E
H6	110	1.09	E

1/ Possibilities were "broken out", 1; or "intact", 2.

Table 34. Duncan's multiple range test for the variable "distance from a snag to the nearest overstory tree" by old-growth forest type, Prince of Wales Island, Alaska, 1977.

Stand type	Number	Mean distance from a snag to the nearest living over-story tree (feet)	Means with the same letter are not significantly different at alpha level = 0.05
S7	20	15.2	A
H6	110	13.9	A
HS6	120	13.3	A
HS7	107	13.2	A
H7	108	12.8	A
HS5	38	12.1	A B
C4	24	11.5	A B
H5	177	11.2	A B
H4	106	11.1	A B
ScM	91	10.4	A B
ScL	102	8.5	B

Table 35. Duncan's multiple range test for the variable "distance from a snag to the nearest overstory tree" by species, old-growth forests, Prince of Wales Island, Alaska, 1977

Species	Number	Mean distance to the nearest living tree in the dominant overstory	Means with the same letter are not significantly different at alpha level = 0.05
Western hemlock	516	13.2	A
Hemlock	83	12.1	A B
Sitka spruce	65	11.5	A B C
Lodgepole pine	10	10.7	A B C
Unknown	179	10.6	B C
Alaska-cedar	62	9.8	B C
Cedar	48	8.9	B C
Western redcedar	36	8.5	C
Mountain hemlock	3	6.7	C

Distance Between Snags

The maximum distance between snags was 112 feet; the average was 22.4 feet (Standard deviation = 15.9 feet). However, mean distance between snags varies significantly among forest types. It is significantly less in ScL (19.6 feet), ScM 17.6 feet, H4 (17.0 feet), and C4 (9.3 feet) than in S7, while ScM, H4, and C4 values are significantly less than the mean in ScL. Other significant differences exist among forest types and species (tables 36 and 37).

The ratio between the mean distance to nearest snag and the mean distance to nearest overstory tree. For a given area, stand, forest type and so forth, is an indication of the availability of snags relative to living trees. In old-growth of central Prince of Wales Island, the ratio varies from 0.81 to 2.31 depending upon forest types. The ratios are:

ScL - 2.31
S7 - 2.28
HS5 - 2.09
H7 - 2.06
H5 - 2.04
HS6 - 1.95
HS7 - 1.82
H6 - 1.73
ScM - 1.69
H4 - 1.53
C4 - 0.81

Table 36. Duncan's multiple range test for the variable "distance to the nearest snag" by old-growth forest type, Prince of Wales Island, Alaska, 1977.

Stand type	Number	Mean distance to the nearest snag (feet) 1/	Means with the same letter are not significantly different at alpha level = 0.05
SH	20	34.6	A
H7	108	26.4	A B
HS6	120	26.0	A B
HS5	38	25.3	A B C
HS7	107	24.0	A B C
H6	110	24.0	A B C
H5	177	22.8	A B C
ScL	102	19.6	B C D
ScM	91	17.6	C D
H4	106	17.0	C D
C4	24	9.3	D

1/ The average distance between snags in feet.

Table 37. Duncan's multiple range test for the snag variable "distance to the nearest snag" by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

Species	Number	Mean distance to the nearest snag (feet) 1/	Means with the same letter are not significantly different at alpha level = 0.05
Western hemlock	516	24.6	A
Lodgepole pine	10	24.5	A B
Western redcedar	36	23.2	A B
Sitka spruce	65	22.2	A B
Unknown	179	21.4	B
Mountain hemlock	3	19.7	B
Alaska-cedar	62	16.0	B
Cedar	48	14.4	B

1/ Distance from a snag of this species to the nearest snag regardless of the nearest snag's species.

Figure 4. Snag density, depending upon stand type, varies from 8 to 60 per acre in old-growth forests of Prince of Wales Island, Alaska, July, 1977.

Figure 5. The average distance from a snag to an overstory tree is 11.9 feet in old-growth forests of Prince of Wales Island, Alaska, July, 1977.

Additional Data Analysis

Several other tests and analysis of the collected field data were made which gives additional information on snag characteristics in old-growth forests. These data are presented in the appendix.

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Table 38. Matrix of correlation coefficients among 21 site and snag variables in hemlock-spruce old-growth forest, Prince of Wales Island, Alaska, 1977.

	Slope	Basal area	Crown density	Height dominants	No. snags below minimums	Number snags	DBH	Sound	Top	Percent bark	Lean	Limbs	Percentage above canopy	Distance to living tree	Distance to snag	No. natural cavities	No. animal made cavities	Age	Height	Number trees
Elevation	.44**	.17**	.19**	.30**	.01	.27**	.19**	.09*	.07*	.002	.07*	.03	.09*	-.11**	-.18**	.01	-.03	-.03	.04	-.10**
Slope		.06	.22**	.20**	.19**	.18**	.0022	-.04	-.09**	.12**	.01	-.03	-.11**	.02	-.07*	-.03	.06	-.06	.03	.02
Basal area per acre			.66**	.45**	-.12**	.002	.23**	-.07*	-.14**	.10**	.08**	-.04	-.16**	-.008	.07*	-.08**	.005	-.03	.05	.76**
Crown density percentage				.60**	-.27**	-.15**	.33**	-.09**	.20**	.10*	-.13**	-.03	-.23**	.04	.11**	-.08**	.03	-.008	.08**	.53**
Height of dominant overstory					-.46**	-.27**	.47**	-.08*	-.24**	.14**	-.15**	-.02	-.32**	.18**	.23**	-.03	.03	-.05	.09**	.23**
Number snags below minimum size						.15**	.29**	.05	.20**	.08**	.11**	.03	.15**	-.14**	-.10**	.02	-.02	-.02	-.05	-.11**
Number snags per plot							-.17**	.06*	.14**	.03	.15**	.08**	.08**	-.03	-.41**	-.02	-.06	-.06	.01	.08*
dbh of a snag								-.21**	-.18**	-.05	-.17**	.02	-.07*	.11**	.12**	.007	.06	.14**	.10**	.05
Soundness									.49**	.50**	.02	.51**	.17**	.02	-.03	.03	.0007	-.66**	.57**	-.06
Condition of snag's top										.25**	.04	.64**	.35**	.02	-.06*	.04	.004	-.50**	.58**	-.11**
Percentage of snag covered by bark											.09**	.44**	.05	.10**	.02	.04	-.04	-.73**	.42**	.05
Degree of lean from the vertical												-.09**	.002	-.05	-.06*	-.002	-.004	.97*	-.06**	-.08*
Number of limbs													.26**	.10**	-.004	-.04	.03	-.64**	.73**	-.06
Percentage of snag extending above the canopy														-.04	-.06*	-.02	-.02	-.13**	.21**	-.10**
Distance to nearest living tree in the overstory															-.04	.12**	-.01	-.09**	.11**	-.11**
Distance to nearest snag																.003	.03	.01	.02	.03
Number of natural cavities per snag																	.05	.03	.03	-.08*
Number animal-made cavities per snag																		.04	.05	-.01
Age of snag																			-.60**	-.04
Height of snag																				.03
Number overstory trees per plot																				

*P ≤ 0.05
**P ≤ 0.01

Table 39. Significant variables related to the number of natural cavities and the number of animal-made cavities in a snag, Prince of Wales Island, Alaska, 1977.

Variable	Number	r [1]	R^2 (%) [2]
	Natural Cavities		
Basal area of stand	1,000	-0.083 [3]	0.7
Crown density of stand	1,003	-0.083 [3]	0.7
Number of trees per acre (10 inches dbh and greater)	814	-0.081 [4]	0.7
	Animal-made Cavities		
dbh of snag	1,003	0.063 [4]	0.4

[1] Varies from -1 to +1 with 1 being perfect correlation.

[2] The percentage variation in the number of natural cavities in a snag explained by the tabled variable.

[3] $P \leq 0.01$

[4] $P \leq 0.05$

Table 40. Significant variables related to snag height, Prince of Wales Island, Alaska, 1977.

Variable	Number	r [1]	R^2 (%) [2]
Crown density of stand	1,003	0.082	0.7
Height of dominant canopy	994	0.089	0.8
dbh of snag	1,003	0.102	1.0
Snag soundness	1,002	0.574	33.0
Conditions of top	1,003	0.577	33.3
Percentage covered by bark	1,002	0.422	17.8
Number of limbs	1,003	0.733	53.7
Percentage of snag above canopy	1,003	0.211	4.4
Age of snag	1,002	-0.598	35.8

[1] Varies from -1 to +1 with 1 being perfect correlation. $P \leq 0.01$

[2] The percentage variation in snag height explained by the tabled variable.

Table 41. Significant variables related to the dbh of a snag, Prince of Wales Island, Alaska, 1977.

Variable	N	r [1]	R^2 (%) [2]
Elevation (feet)	811	-0.188	3.5
Basal area of stand (sq. ft/acre)	1,000	0.232	5.4
Crown density of stand (sq. ft)	1,003	0.327	10.7
Height of dominant canopy (feet)	994	0.468	21.9
Number of below minimum snags	996	-0.290	8.4
Number snags per unit area	1,002	-0.168	2.8
Soundness of snags (relative)	1,002	-0.207	4.3
Condition of top	1,003	-0.181	3.3
Snag lean (percentage)	1,001	-0.169	2.9
Percentage of snag above canopy	1,003	-0.074 [3]	0.6
Snag age	1,002	0.138	1.9
Snag height (feet)	1,003	0.102	1.0

[1] Varies from -1 to +1 with 1 being perfect correlation. $P \leq 0.01$

[2] The percentage variation in dbh of a snag explained by the tabled variable.

[3] P 0.05

Table 42. Significant variables related to percentage snag covered with bark, Prince of Wales Island, Alaska, 1977.

Variable	Number	r [1]	R^2 (%) [2]
Slope	995	0.125	1.6
Basal area of stand	999	0.105	1.1
Crown density of stand	1,002	0.097	0.9
Height of dominant canopy	993	0.144	2.1
Number below minimum snags	995	-0.084	0.1
Soundness of the snag	1,001	0.497	24.7
Condition of top	1,002	0.248	6.2
Snag lean	1,000	-0.087	0.8
Number limbs on snag	1,002	0.436	19.0
Age of snag	1,001	-0.730	53.3
Height of snag	1,002	0.422	17.8

[1] Varies from -1 to +1 with 1 being perfect correlation. $P \leq 0.01$

[2] The percentage variation in percentage of a snag covered with bark explained by the tabled variable.

[3] $P \leq 0.05$

Table 43. Significant variables related to snag soundness, Prince of Wales Island, Alaska, 1977.

Variable	N	r [1]	R^2 (%) [2]
Elevation	810	0.087 [3]	0.8
Basal area of stand	999	-0.070 [3]	0.5
Crown density of stand	1,002	-0.092	0.8
Canopy height	993	-0.076 [3]	0.6
Snag density	1,001	0.065 [3]	0.4
dbh of snag	1,002	-0.207	4.3
Condition of snag top	1,002	0.490	24.0
Percentage of snag covered by bark	1,001	0.497	24.7
Number of limbs on snag	1,002	0.505	25.5
Percentage of snag above canopy	1,002	0.169	2.9
Age of snag	1,001	-0.662	43.8
Height of snag	1,002	0.574	33.0

[1] Varies from -1 to +1 with 1 being perfect correlation. $P \leq 0.01$

[2] The percentage variation in snag soundness explained by the tabled variable.

[3] $P \leq 0.05$

Table 44. Significant variables related to distance from a snag to an overstory tree, Prince of Wales Island, Alaska, 1977.

Variable	Number	r 1/	R^2 (%) 2/
Elevation	811	-0.110	1.2
Canopy height	994	0.185	3.4
Number below minimum snags	996	-0.137	1.9
dbh of snag	1,003	0.112	1.2
Percentage of snag covered by bark	1,002	0.104	1.1
Number limbs on snag	1,003	0.097	0.9
Number natural cavities in snag	1,003	0.119	1.4
Age of snag	1,002	-0.090	0.8
Snag height	1,003	0.110	0.4
Number trees per unit area 10 inches dbh or greater	814	-0.114	1.3

1/ Varies from -1 to +1 with 1 being perfect correlation. $P \leq 0.01$

2/ The percentage variation in the distance from a snag to an overstory tree explained by the tabled variable.

Table 45. Significant variables related to distance from one snag to another snag, Prince of Wales Island, Alaska, 1977

Variable	Number	r 1/	R^2 (%) 2/
Elevation	811	-0.179	3.2
Slope	996	-0.072 3/	0.5
Basal area of stand	1,000	0.070 3/	0.5
Crown density of stand	1,003	0.110	1.2
Height of canopy	994	0.226	5.1
Number below minimum snags	996	-0.104	1.1
Snag density	1,002	0.409	16.7
dbh of snag	1,003	0.120	1.4
Condition of top	1,003	-0.062 3/	0.4
Snag lean	1,001	-0.064 3/	0.4
Percentage of snag above canopy	1,003	-0.062 3/	0.4

1/ Varies from -1 to +1 with 1 being perfect correlation. $P \leq 0.01$

2/ The percentage variation in distance from one snag to another snag explained by the tabled variable.

3/ $P \leq 0.05$

Table 46. Average snag height in feet by species, old-growth forest, Prince of Wales Island, Alaska, 1977.

	Western hemlock	Mountain hemlock	Hemlock[1/]	Sitka spruce	Western redcedar	Alaska-cedar	Cedar[2/]	Lodgepole pine	Unknown[3/]
Number of observations	516	3	83	65	36	62	48	10	179
Mean	49.2	57.0	45.7	51.7	53.5	52.2	54.9	43.6	28.6
Standard deviation	36.8	14.1	32.3	40.5	32.9	20.9	24.6	15.7	17.3
Minimum value	10.0	42.0	10.0	11.0	10.0	12.0	12.0	24.0	10.0
Standard error of the mean	1.618	8.144	3.5	5.029	5.481	2.660	3.556	4.974	1.295
Coefficient of variation	74.7	24.7	70.7	78.4	61.5	40.1	44.9	36.1	60.6

1/ Includes both western hemlock and mountain hemlock

2/ Includes both western redcedar and Alaska-cedar

3/ Identification of species not possible. However, all the individuals in this category were of the previously listed species, genus (*Tsuga*), or group, (*Thuga* and *Chamaecyparis*) except no lodgepole pine is represented.

Table 47. Age of snag by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

	Western hemlock	Mountain hemlock	Hemlock[1/]	Sitka spruce	Western redcedar	Alaska-cedar	Cedar[2/]	Lodgepole pine	Unknown[3/]
Number of observations	516	3	83	64	36	62	48	10	179
Mean [4/]	2.2	2.3	2.2	2.4	2.4	2.0	2.3	2.3	2.9
Standard deviation	0.7	0.6	0.7	0.7	0.7	0.8	0.8	0.7	0.3
Minimum value	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Maximum value	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Standard error of the mean	0.032	0.333	0.082	0.091	0.121	0.104	0.119	0.213	0.020
Coefficient of variation	32.7	24.7	33.1	30.4	30.5	40.0	36.0	29.3	9.0

1/ Includes both western hemlock and mountain hemlock

2/ Includes both western redcedar and Alaska-cedar

3/ Identification of species not possible. However, all the indiyiduals in this category were of the previously listed species, genus (Tsuga), or group (Thuga and Chamaecyparis) except no lodgepole pine is represented.

4/ Higher the value, greater the age (categories were recent, 1; old, 2; and very old, 3).

Table 48. Number of animal-made cavities per snag by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

	Western hemlock	Mountain hemlock	Hemlock[1/]	Sitka spruce	Western redcedar	Alaska-cedar	Cedar[2/]	Lodgepole pine	Unknown[3/]
Number of observations	516	3	83	64	36	62	48	10	179
Mean	0.054	0.0	0.036	0.015	0.056	0.0	0.0	0.0	0.078
Standard deviation	0.424	0.0	0.329	0.124	0.333	0.0	0.0	0.0	0.545
Minimum value	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum value	6.0	0.0	3.0	1.0	2.0	0.0	0.0	0.0	6.0
Standard error of the mean	0.019	0.0	0.035	0.015	0.056	0.0	0.0	0.0	0.041
Coefficient of variation	780.9	---	911.0	806.2	600.0	---	---	---	697.0

1/ Includes both western hemlock and mountain hemlock

2/ Includes both western redcedar and Alaska-cedar

3/ Identification of species not possible. However, all the individuals in this category were of the previously listed species, genus (*Tsuga*), or group (*Thuga* and *Chamaecyparis*) except no lodgepole pine is represented.

Table 49. Number of natural cavities per snag by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

	Western hemlock	Mountain hemlock	Hemlock[1/]	Sitka spruce	Western redcedar	Alaska-cedar	Cedar[2/]	Lodgepole pine	Unknown[3/]
Number of observations	516	3	83	65	36	62	48	10	179
Mean	0.058	0.0	0.0	0.015	0.083	0.064	0.021	0.0	0.123
Standard deviation	0.374	0.0	0.0	0.124	0.368	0.248	0.144	0.0	1.140
Minimum value	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum value	6.0	0.0	0.0	1.0	2.0	1.0	1.0	0.0	15.0
Standard error of the mean	0.016	0.0	0.0	0.015	0.061	0.031	0.021	0.0	0.085
Coefficient of variation	644.3	---	---	806.2	442.1	383.9	692.8	---	927.5

1/ Includes both western hemlock and mountain hemlock

2/ Includes both western redcedar and Alaska-cedar

3/ Identification of species not possible. However, all the individuals in this category were of the previously listed species, genus (Tsuga), or group (Thuga and Chamaecyparis) except no lodgepole pine is represented.

Table 50. Distance in feet from one snag to another snag by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

	Western hemlock	Mountain hemlock	Hemlock[1/]	Sitka spruce	Western redcedar	Alaska-cedar	Cedar[2/]	Lodgepole pine	Unknown[3/]
Number of observations	516	3	83	65	36	62	48	10	179
Mean	24.6	19.7	20.5	22.2	23.2	16.0	14.4	24.5	21.4
Standard deviation	16.5	15.6	14.1	15.0	15.1	12.2	10.2	31.7	15.4
Minimum value	0.0	5.0	1.0	0.0	0.0	1.0	1.0	7.0	0.0
Maximum value	107.0	36.0	63.0	60.0	65.0	54.0	39.0	112.0	81.0
Standard error of the mean	0.727	8.988	1.550	1.860	2.520	1.545	1.478	10.018	1.154
Coefficient of variation	67.2	79.2	68.9	67.6	65.1	76.1	71.0	129.3	72.0

1/ Includes both western hemlock and mountain hemlock

2/ Includes both western redcedar and Alaska-cedar

3/ Identification of species not possible. However, all the individuals in this category were of the previously listed species, genus (Tsuga), or group (Thuga and Chamaecyparis) except no lodgepole pine is represented.

Table 51. Distance in feet from a snag to the nearest living tree in the dominant canopy, by snag species, old-growth forests, Prince of Wales Island, Alaska, 1977.

	Western hemlock	Mountain hemlock	Hemlock[1/]	Sitka spruce	Western redcedar	Alaska-cedar	Cedar[2/]	Lodgepole pine	Unknown[3/]
Number of observations	516	3	83	65	36	62	48	10	179
Mean	13.2	6.7	12.1	11.5	8.5	9.8	8.9	10.7	10.6
Standard deviation	7.9	6.6	7.5	8.6	6.6	7.0	7.0	12.1	8.1
Minimum value	0.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0
Maximum value	42.0	14.0	30.0	42.0	31.0	28.0	32.0	38.0	45.0
Standard error of the mean	0.349	3.844	0.823	1.074	1.100	0.894	1.011	3.830	0.603
Coefficient of variation	60.2	99.9	62.1	75.4	77.9	71.9	78.7	113.2	76.4

1/ Includes both western hemlock and mountain hemlock

2/ Includes both western redcedar and Alaska-cedar

3/ Identification of species not possible. However, all the individuals in this category were of the previously listed species, genus (*Tsuga*), or group (*Thuga* and *Chamaecyparis*) except no lodgepole pine is represented.

Table 52. Percentage of snag extending above the dominant canopy by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

	Western hemlock	Mountain hemlock	Hemlock[1/]	Sitka spruce	Western redcedar	Alaska-cedar	Cedar[2/]	Lodgepole pine	Unknown[3/]
Number of observations	516	3	83	65	36	62	48	10	179
Mean	0.6	7.7	1.7	1.5	7.8	7.9	9.0	0.0	1.4
Standard deviation	5.2	13.3	6.6	6.0	19.7	15.3	19.8	0.0	7.1
Minimum value	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum value	96.0	23.0	37.0	43.0	87.0	63.0	96.0	0.0	52.0
Standard error of the mean	0.230	7.667	0.724	0.741	3.287	1.948	2.862	0.0	0.434
Coefficient of variation	865.0	173.2	394.1	396.1	254.5	194.9	219.8	---	495.5

1/ Includes both western hemlock and mountain hemlock

2/ Includes both western redcedar and Alaska-cedar

3/ Identification of species not possible. However, all the individuals in this category were of the previously listed species, genus (*Tsuga*), or group (*Thuga* and *Chamaecyparis*) except no lodgepole pine is represented.

Table 53. Number of limbs on snags, by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

	Western hemlock	Mountain hemlock	Hemlock[1/]	Sitka spruce	Western redcedar	Alaska-cedar	Cedar[2/]	Lodgepole pine	Unknown[3/]
Number of observations	516	3	83	65	36	62	48	10	179
Mean	15.7	48.0	14.4	16.6	20.1	30.7	28.6	20.7	1.2
Standard deviation	29.9	44.8	26.5	30.9	34.2	35.6	37.3	29.9	4.4
Minimum value	0.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum value	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	37.0
Standard error of the mean	1.315	25.865	2.913	3.837	5.700	4.524	5.379	9.450	0.329
Coefficient of variation	190.5	93.5	184.2	186.8	169.8	116.0	130.1	144.4	378.8

1/ Includes both western hemlock and mountain hemlock

2/ Includes both western redcedar and Alaska-cedar

3/ Identification of species not possible. However, all the individuals in this category were of the previously listed species, genus (Tsuga), or group (Thuga and Chamaecyparis) except no lodgepole pine is represented.

Table 54. Snag lean, by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

	Western hemlock	Mountain hemlock	Hemlock[1/]	Sitka spruce	Western redcedar	Alaska-cedar	Cedar[2/]	Lodgepole pine	Unknown[3/]
Number of observations	515	3	83	65	36	62	48	10	178
Mean	1.2	1.7	2.3	1.0	5.4	4.2	3.0	0.9	3.3
Standard deviation	4.2	2.9	5.9	3.5	10.7	10.6	6.9	1.9	8.9
Minimum value	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum value	40.0	5.0	30.0	20.0	50.0	63.0	35.0	5.0	65.0
Standard error of the mean	0.187	1.667	0.644	0.430	1.777	1.350	0.999	0.605	0.666
Coefficient of variation	354.6	173.2	251.2	346.4	197.9	253.5	227.5	212.4	267.7

1/ Includes both western hemlock and mountain hemlock

2/ Includes both western redcedar and Alaska-cedar

3/ Identification of species not possible. However, all the individuals in this category were of the previously listed species, genus (Tsuga), or group (Thuga and Chamaecyparis) except no lodgepole pine is represented.

Table 55. Percentage of snag bark covered, by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

	Western hemlock	Mountain hemlock	Hemlock[1/]	Sitka spruce	Western redcedar	Alaska-cedar	Cedar[2/]	Lodgepole pine	Unknown[3/]
Number of observations	515	3	83	65	36	62	48	10	179
Mean	64.361	35.0	59.0	37.5	35.7	44.4	41.8	43.2	0.868
Standard deviation	40.418	47.0	37.4	35.1	39.8	39.3	40.2	40.5	7.5
Minimum value	0.0	5.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0
Maximum value	100.0	90.0	100.0	100.0	100.0	100.0	100.0	100.0	95.0
Standard error of the mean	1.781	27.538	4.106	4.354	6.639	4.988	5.804	12.797	0.561
Coefficient of variation	62.8	136.3	62.9	93.5	111.6	88.4	96.3	93.7	866.7

1/ Includes both western hemlock and mountain hemlock

2/ Includes both western redcedar and Alaska-cedar

3/ Identification of species not possible. However, all the individuals in this category were of the previously listed species, genus (*Tsuga*), or group (*Thuga* and *Chamaecyparis*) except no lodgepole pine is represented.

Table 56. Snag dbh, by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

	Western hemlock	Mountain hemlock	Hemlock[1/]	Sitka spruce	Western redcedar	Alaska-cedar	Cedar[2/]	Lodgepole pine	Unknown[3/]
Number of observations	516	3	83	65	36	62	48	10	179
Mean	25.3	15.0	21.1	29.4	20.5	16.7	18.6	13.1	22.8
Standard deviation	10.6	1.7	8.9	16.5	8.6	6.1	9.8	2.7	11.4
Minimum value	10.0	13.0	10.0	10.0	10.0	10.0	10.0	11.0	10.0
Maximum value	73.0	16.0	47.0	91.0	42.0	37.0	56.0	19.0	67.0
Standard error of the mean	0.467	1.000	0.975	2.048	1.432	0.770	1.414	0.862	0.853
Coefficient of variation	42.0	11.5	42.1	56.1	41.8	36.3	52.7	20.8	50.0

1/ Includes both western hemlock and mountain hemlock

2/ Includes both western redcedar and Alaska-cedar

3/ Identification of species not possible. However, all the individuals in this category were of the previously listed species, genus (*Tsuga*), or group (*Thuga* and *Chamaecyparis*) except no lodgepole pine is represented.

Table 57. Condition of snag's top by species, old-growth forests, Prince of Wales Island, Alaska, 1977.

	Western hemlock	Mountain hemlock	Hemlock[1/]	Sitka spruce	Western redcedar	Alaska-cedar	Cedar[2/]	Lodgepole pine	Unknown[3/]
Number of observations	516	3	83	65	36	62	48	10	179
Mean	1.169	1.667	1.241	1.231	1.472	1.597	1.542	1.300	1.112
Standard deviation	1.380	0.577	0.430	0.425	0.506	0.494	0.504	0.483	0.316
Minimum value	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Maximum value	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Standard error of the mean	0.017	0.333	0.047	0.053	0.084	0.063	0.073	0.153	0.024
Coefficient of variation	32.5	34.6	34.7	34.5	34.4	30.1	32.7	32.7	28.4

1/ Includes both western hemlock and mountain hemlock

2/ Includes both western redcedar and Alaska-cedar

3/ Identification of species not possible. However, all the individuals in this category were of the previously listed species, genus (Tsuga), or group (Thuga and Chamaecyparis) except no lodgepole pine is represented.

Table 58. Analysis of regression of significant site variables on number of snags below minimum in old-growth forests, Prince of Wales Island, Alaska, 1977.

Source	df	MS	F
Total	245	4.495	
Regression	3	87.565	25.27 1/
Error	242	3.465	
best model: 2/	SNMIN = 5.23 + 0.0092 BASALAR - 0.0307 DOMHT - 0.008 ELEV; R^2 = 23.9%		

1/ $P \leq 0.01$

2/ SNMIN = number of snags below minimum per 0.2-acre plot
BASALAR = basal area of stand in ft^2/ acre
DOMHT = height of dominant overstory in feet; and
ELEV = elevation of plot in feet.

Table 59. Analysis of regression of significant site variables on number of snags per 0.2 acre plot in old-growth forests, Prince of Wales Island, Alaska, 1977.

Source	df	MS	F
Total	246	5.685	
Regression	4	48.225	9.68 1/
Error	242	4.982	
best model: 2/	SNAGPLOT = 2.49 + 0.0139 BASALAR + 0.0193 SLOPE = 0.0152 DOHMT + 0.0010 ELEV: R^2 = 13.8%		

1/ $P \leq 0.001$

2/ SNAGPLOT = number of snags per 0.2 acre plot
BASALAR = basal area of stand in ft^2/acre
SLOPE = slope of plot in degrees
DOMHT = height of dominant canopy in feet.
ELEV = elevation of plot in feet.